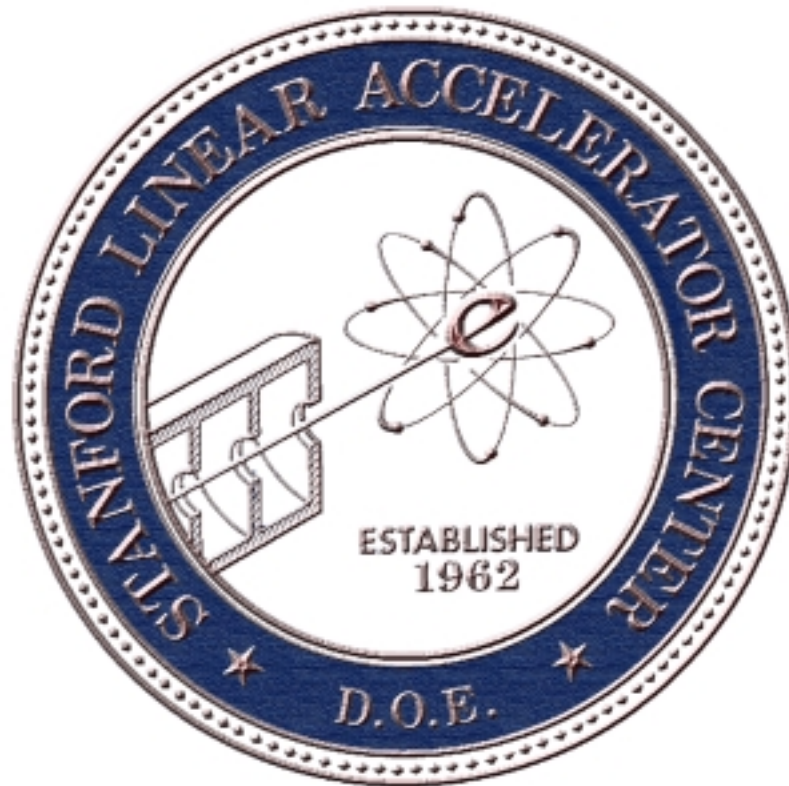


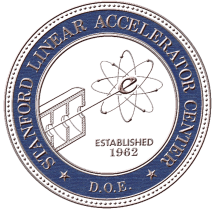
# Perspective on the Future of HEP



By Jonathan Dorfan, SLAC Director

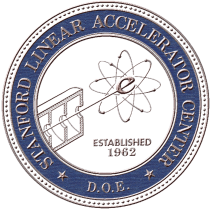
## Snowmass 2001

Sunday, July 1, 2001



# **HEP — A Field on the Cusp of Major Discoveries**

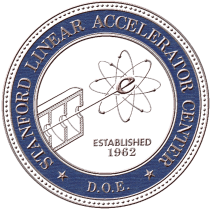
- **High Energy Physics remains an extraordinarily exciting branch of fundamental science:**
  - ↪ **We are faced with answering deep questions whose outcomes are not clear**
  - ↪ **There are major discoveries to be made**
- **The answers to these questions will not come from theory alone — experiment must lead the way**



# **Global Planning — An Imperative**

- **For the world HEP program to remain healthy, we need balance between the regions. In particular, the U.S. program needs to continue its pivotal role in helping to achieve balance**
- **Reduction of investment in HEP by the U.S. will be detrimental to the programs in Europe & Asia. It could send a message to governments in those regions to follow suit**

**We need a 20 year global plan for major facilities:  
The first element in that global plan already exists  
— the LHC**



# Global Planning

- **All three regions have strong programs through this decade**
- **Beyond this decade, however, each region lacks a clear plan. Accordingly, there are long-range planning studies ongoing in each of Asia, Europe and the United States**
  - ✦ **Every effort must be made to co-ordinate the outcomes of these separate planning efforts into a global plan**

**Snowmass is a unique opportunity to begin this process — all three regions are well represented at this workshop**



**International Committee for Future Accelerators**  
**Sponsored by the Particles and Fields Commission of IUPAP**

9 October 2000

Dr. Fred Gilman  
Dr. Lorenzo Foa  
Dr. Sachio Komamiya

Dear Colleagues,

At its recent meeting, ICFA discussed the three ongoing studies, each chaired by one of you, on future facilities for particle physics in your respective country or region. The Committee felt that, while it is not realistic to combine the studies, communication between them should be encouraged, since any one region cannot ignore what happens in the others. ICFA suggests that collaboration between the studies be encouraged in order to reach a global consensus.

In my role as Chairman of ICFA, I would be very happy to assist you in any way to further these goals.

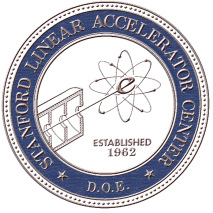
Sincerely,

Hirotaka Sugawara  
Chairman, ICFA

Cc: C. Earnshaw  
R. Rubinstein

Roy Rubinstein, ICFA Secretary, Director's Office, Fermilab, P.O. Box 500, Batavia, IL 60510-0500, USA;  
Tel: 1-630-840-3211; Fax: 1-630-840-2939; E-mail: roy@fnal.gov

Claire Earnshaw, Assistant ICFA Secretary, DSU, CERN, CH-1211 Geneva 23, Switzerland; Tel: 41-22-767-3596;  
Fax: 41-22-767-6760; E-mail: Claire.Earnshaw@cern.ch



# What Are the Physics Drivers?

## 1) The origin of Flavor

↪ Striking experimental evidence with a relatively poor understanding

💧 Why 3 flavors? What's going on in the  $\nu$  Sector?

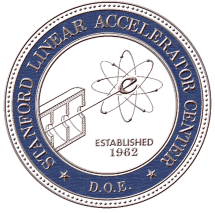
💧 What is the origin of CP violation? Baryogenesis?

## 2) The origin of Dark Matter / Dark Energy and extremely high energy cosmic rays / gamma rays

↪ What comprises the Dark Matter?

↪ What is the mysterious force accelerating the outer edges of our Universe?

↪ What are the mechanisms that generate such enormous cosmic accelerations?

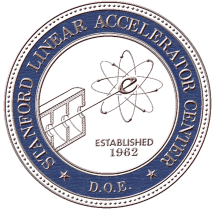


# What Are the Physics Drivers? (continued)

## 3) The origin of Electro-weak Symmetry Breaking (EWSB)

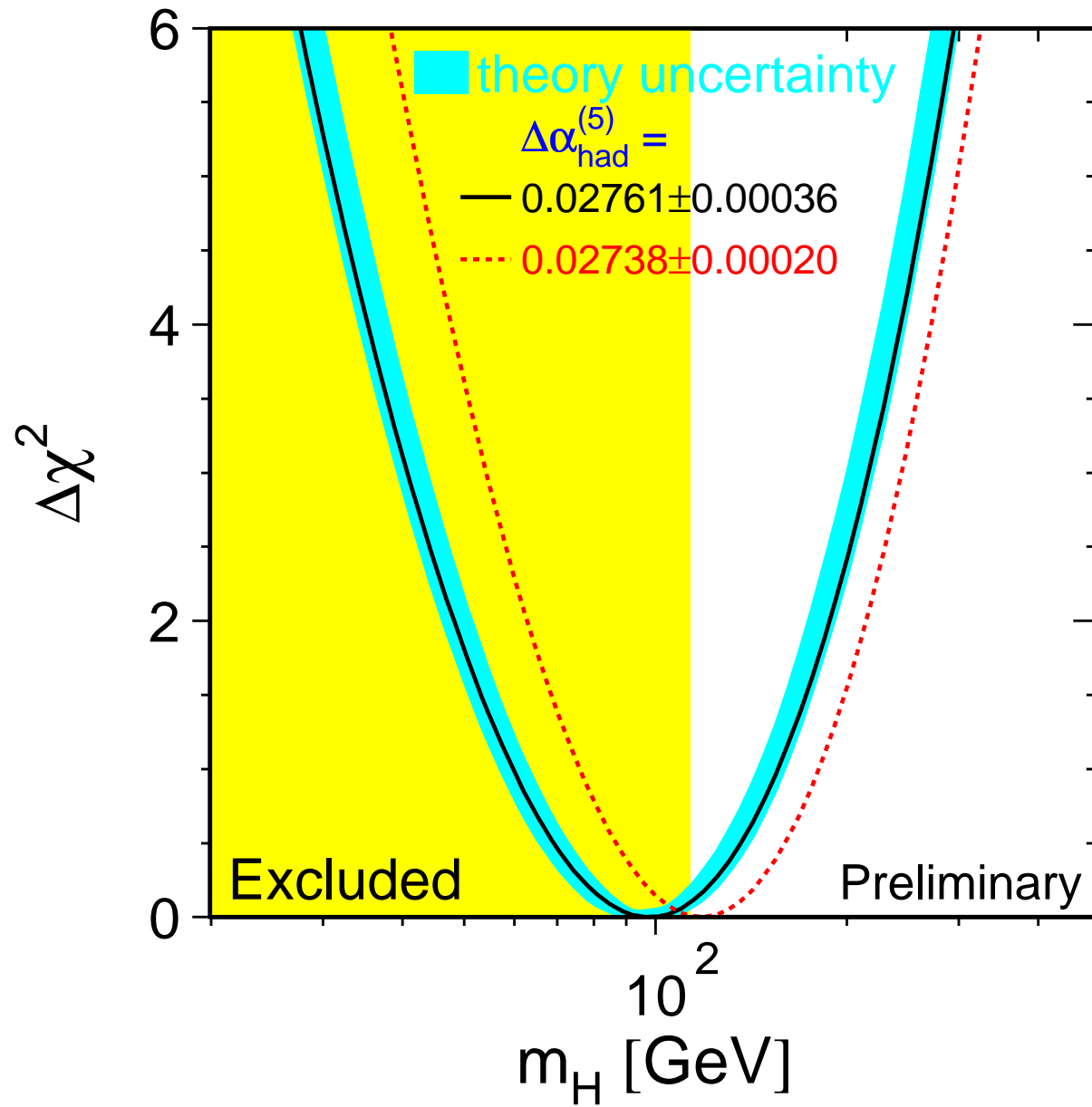
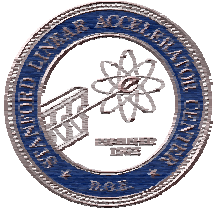
- ✚ We have clear evidence for EWSB, but no clear understanding of the mechanism. Different mechanisms portend very different consequences

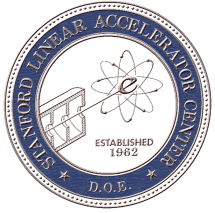
**There is a compelling need for a thorough exploration of EWSB**



# Exploring EWSB

- **The Tevatron and LHC provide a powerful proton-based probe. The LHC is critical – it provides a very large discovery reach**
- **However, the LHC is not sufficient for a full understanding of this question**
- **With a companion  $e^+e^-$  linear collider (LC) we will be able to unravel the origin of EWSB**
- **Major lesson of the past 30 years is the necessity for complementary probes. Without the strength of both proton and electron machines, we would not have the clear and detailed picture we call the Standard Model**





# Exploring EWSB (continued)

- **Physics arguments in favor of a 500 GeV c.m. LC are now compelling. With time, higher energy  $e^+e^-$  collisions will be needed which argues for building a machine that can be upgraded in energy**

**Realizing a LC at 500 GeV c.m. initial energy as a companion machine to the LHC is an urgent need for the worldwide HEP Community**

**It will be expensive and for many reasons it must be realized as an International Project**



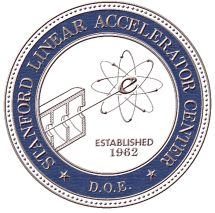
# Exploring EWSB

(continued)

---

- **Given its long history of involvement with the development of linear colliders:**

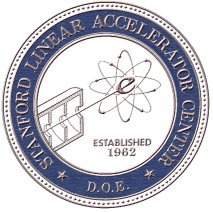
**SLAC commits itself to playing a central role in the construction and operation of the future Linear Collider, in the construction of the detector and in the physics program, independently of where the facility is built and independently of the technology**



# United States Program — Planning the Next 20 Years

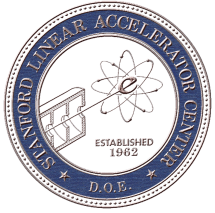
- **The absence of a clearly articulated plan for the future of HEP in the United States is very damaging:**
  - ✦ Congress and the Administration are in desperate need of a community-supported plan that lays down unambiguous priorities
  - ✦ Lacking a plan, we are greatly hampered in our ability to participate in global planning with our regional partners

**The work of the HEPAP Sub-panel is critical to ensuring a healthy future for U.S. HEP. Widespread Community participation in reaching a plan that has the support of the community is essential**



# United States Program Planning

- The near-term program in the U.S. is very strong — it is discovery-oriented and guarantees a decade of frontier science. It is providing exciting opportunities for the worldwide community
- Tevatron needs to complete the planned  $L$  upgrade to  $5 \times 10^{32} \text{ cm}^{-2} \text{ sec}^{-1}$  to stretch Higgs / Susy and  $b$  physics reach
- Heavy Flavor Sector  
 $B$  Factories have demonstrated they can do the science.  
PEP-II needs to complete the planned upgrade to  $L = 2 \times 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$
- May eventually need to go to  $L \approx 10^{36} \text{ cm}^{-2} \text{ sec}^{-1}$  with  $e^+e^-$  machines — physics will be the guide



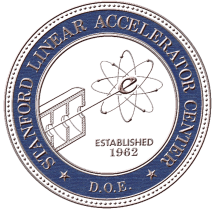
# U.S. Program Planning

## 💧 Neutrino Sector

⇒ Impressive worldwide program of:

long baseline experiments (Numi/Minos, K2K, CERN / Gran Sasso),  
Mini-Boone, Super-K, SNO, Cherenkov Arrays

⇒ By  $\approx 2006$ , we will know a lot more about  $\nu$  sector.  
This will determine whether the muon storage ring neutrino source is the appropriate next step. In the meantime, pursue R&D for this facility aggressively



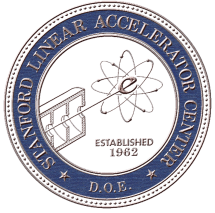
# **U.S. Program Planning (continued)**

---

- **Particle Astro-physics**

- **Rapidly evolving field – explosion of profound data and theoretical activity**
- **New round of powerful instruments is planned / ongoing (SNAP, GLAST, CDMS, AUGER, SDSS)**

**Clear that non-accelerator physics will require a larger investment than has been traditional**



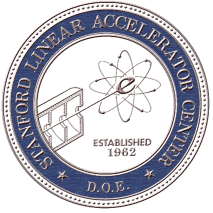
# **U.S. Program Planning (continued)**

---

- **Advanced Accelerator R&D**

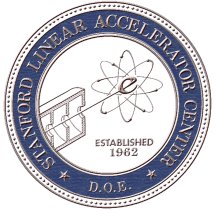
- ⇒ **Advanced Accelerator research is critical to the future of particle physics**

- ⇒ **We must continue to explore technologies that go significantly beyond the approaches currently under discussion for the next round of machines**



# **The Need for a Frontier Facility**

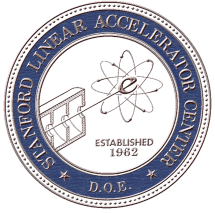
- **Astro-particle physics and upgrades of our present facilities, exciting as they are, cannot provide a sustaining, world class U.S. HEP program beyond this decade**
- **The long-term health of HEP in the United States depends critically on having a frontier facility in the U.S.**
  - ⇒ **Without such a facility, the U.S. program will wither away**
  - ⇒ **A balanced worldwide program requires it. The U.S. needs to play its part in maintaining a healthy worldwide program**



# The Need for a Frontier Facility (continued)

- The U.S. has not built a frontier facility since the completion of SLAC in 1966 and FNAL in 1971
- Physics dictates the choice for this frontier machine — what is needed is a 500 GeV c.m.  $e^+e^-$  LC

**The single most critical recommendation for the HEPAP sub-panel to articulate is the necessity for U.S. participation in a 500 GeV c.m.  $e^+e^-$  LC and the importance for the U.S. to host such an international enterprise**



# Linear Collider — What Technology?

## (continued)

- There are currently two technologies with demonstrated technical capability to build a 500 GeV LC:
  - a) TESLA
  - b) X-band
- SLAC and its partner KEK continue to invest heavily in the X-band technology because it is the route to higher collision energies
  - ⇒ Provides the path to  $\gtrsim 1$  TeV
  - ⇒ Two-beam approach, which is the likely path to multi-TeV  $e^+e^-$  collisions, requires the learning curve of a lower energy X-band machine

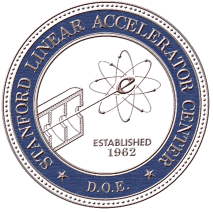


# **Linear Collider — What Technology?**

## **(continued)**

---

- **The World HEP community has begun a process which will provide a relative evaluation of the two LC technology options — this process needs to be completed by the end of 2002**
- **In addition, discussions have begun on how to realize an International Laboratory — realistic models need to be formulated on a timescale similar to the technology comparison**



# Summary

---

- **Global planning and collaboration in accelerator and detector R&D, and in the execution of major facilities for HEP and Particle Astrophysics is an imperative**
- **Snowmass provides a unique forum for discussing and advancing this goal**
- **The U.S. is urgently in need of a community-supported long range plan — it is our collective obligation to help the HEPAP Sub-panel generate such a plan**



# Summary

## **In regard to the Sub-panel process:**

- **The U.S. HEP/Astro-particle program is very well positioned to produce outstanding science during this decade. The sub-panel should endorse increased support for facility operations and extensions of this program that maximize the physics yield**
- **The sustainability of the U.S. HEP program beyond this decade requires an energy frontier facility in the U.S.  
Physics dictates that:**

**The single most critical recommendation for the sub-panel is to articulate the necessity for U.S. participation in a 500 GeV c.m. LC and the importance for the U.S. to host such an international enterprise**